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(12) # EUROPEAN PATENT APPLICATION

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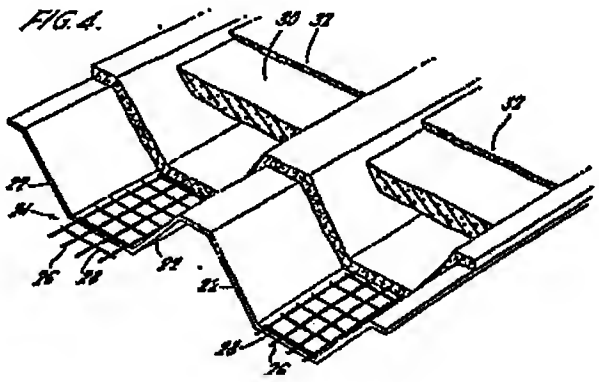
(54) **Improvements in fibre reinforced cement.**

(57) A building panel comprises a layer of glass reinforced cement (12) cast in a mould (20, 22) to a required thickness or thicknesses. In order to reinforce the structure and also to resist cracking during hardening of the material a mesh of reinforcement (24) is embedded in at least a part of the layer (12), the elements (26, 28) of the mesh (24) being fixed together to support the material through the reinforced zone.

FIG. 4.



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IMPROVEMENTS IN FIBRE REINFORCED CEMENT

Glass fibre reinforced cement ("GRC") has been known for many years. The main advantages of the material are that, at least initially, it has a high flexural strength compared with concrete; in view of its high cement content it is extremely weather-resistant; and it can be formed into thin shaped sheets of the order of 10mm thick with a pleasing surface texture. Thus, the material is useful in making, for example, permanent formwork is erected from GRC panels, and concrete is then cast using the GRC panels as a mould with the panels supporting the pressure of the concrete whilst it sets. The concrete bonds to the GRC panels, which form a permanent, weather-resistant, aesthetically pleasing, outer skin to the cast concrete. Furthermore, the GRC panels are usually designed so that during construction they are sufficiently strong to support a workman's weight, and this is especially advantageous when GRC is used in the construction of bridge decking.

GRC does, however, have some disadvantages. Early on in the development of GRC, alkali attack of the glass fibres was a serious problem. It has been alleviated to some extent by the use of special glass, for example, glass having a high zirconium content. Nevertheless, aging is still a problem. As the material is reduced, until after about twenty years in normal weather conditions the glass fibres have little effect at all on the material. Figure 1 of the accompanying drawings is a stress-strain diagram for GRC, the full line and dashed line showing the behavious of young GRC and aged GRC, respectively, in tension. For moderate stresses, both young and aged GRC act substantially as elastic

materials. With larger stresses aged GRC fails, but young GRC does not, the stress being taking to a substantial extent by the glass fibres. Building structures are usually designed so that the GRC is stressed only in the elastic region. However, due to incorrect design calculations or overloading of the structure, the GRC may be subjected to stresses above the elastic limit. Young GRC can withstand such stresses, but aged GRC will crack. Furthermore, repeated excessive loading of young GRC will break down the glass-fibre matrix with the result that after a short time the material will exhibit similar properties to aged GRC. A further disadvantage of GRC is that it shrinks more than concrete and except in the case of relatively small elements or members, cracks tend to occur in the weakest zone.

In summary, therefore, whilst GRC can assist in the production of concrete structures and can initially provide a weather-resistant, aesthetically-pleasing outer skin for the concrete, with time and/or excessive loading the GRC cracks and thus its weather resistance and aesthetic appeal are reduced.

The object of the present invention is to provide a material which has the advantage of GRC as described above but which suffers to a lesser extent from at least some of the disadvantages described above.

This invention provides a building panel composed of, or having an outer layer of fibre reinforced cement, with an arrangement of tension resistant reinforcement embedded in at least a part of the panel or adjacent the fibre reinforced cement, the reinforcement comprising a multiplicity of elongate members secured together where they intersect to constrain the material of the panel

throughout the zone in which the reinforcement lies.

Preferably, the arrangement of reinforcement comprises a mesh. The reinforcement is preferably of steel, which may be galvanised or stainless, but the mesh may be of high modulus plastics material, eg, "Netlon" (Trade Mark).

The fibre in the fibre reinforced cement is preferably of glass, but it may be one or more of the following materials: glass fibre, mineral fibre, steel fibre, high modulus synthetic fibre and vegetable fibre.

In accordance with a second aspect of the present invetion, there is provided a permanent formwork panel comprising a building panel according to said first aspect of the present invention.

In accordance with a third aspect of the present invention, there is provided a building structure having an outer surface provided by a permanent formwork panel according to said second aspect of the present invention, and a structural concrete portion bonded to the permanent formwork panel.

When the formwork panel of the building structure is loaded in tension, the reinforcement arrangement of the panel takes the stress to a substantial extent and thus the stress pattern across the panel is even or varies progressively rather than having discontinuities due to the onset of cracking. In turn, the fibre reinforcement in the cement reinforces the cement between the elements of the reinforcing arrangement. Thus, there are two levels of reinforcement. On the one hand, the added reinforcement arrangement provides overall reinforcement of the panel and the fibre reinforcement provides localised reinforcement to the cement within the added reinforcement arrangement.

Tests have shown that excessive loading of the panels does not cause few and large cracks, but instead causes micro-cracking within the areas of the reinforcing arrangement, which has little detrimental effect on either the weather resistance of the panel or the appearance of the panel.

In addition to reducing large scale cracking as a result of loading the panel, the inclusion of the reinforcing arrangement also relieves stresses built up in the panel due to curing, creep, moisture and/or thermal movement.

It is, of course, known to provide steel reinforcement in concrete structures in order to increase the ability of the structure to cope with tension. Whilst the reinforcing arrangement employed in the present invention does have that effect, this is not the only effect. The reinforcing arrangement and the reinforcing fibres interact to particular advantage to provide two stages of reinforcement which improve the long-term structural integrity of the panel.

Figure 1 of the drawings has already been described above.

There now follows a description, by way of example, of one specific embodiment of the invention, reference being made to the following drawings in which:

Figure 2 is a partial sectional view of a bridge decking panel according to the invention; and

Figure 3 is a partial perspective view, partly cut away of the panel of Figure 2; and

Figures 4 to 6 illustrate a further embodiment.

Referring to Figures 2 and 3, a bridge decking panel 10 has a lower exterior face 12 and an upper face 14 on which concrete is poured to provide the bridge deck. During construction of the bridge, the

panel spans between two spaced supports with opposite edges 16 of the panel resting on the supports. The panel has a plurality of flat-bottomed V-shaped portions 18, two of which are shown in Figure 2.

The panel is fabricated on a generally horizontal mould shaped to form the lower surface 12 of the panel. Mortar is sprayed generally vertically downwardly onto the mould and at the same time chopped glass fibres, typically 35mm long, are also sprayed to form a random fibre reinforcement in the mortar. The mortar is sprayed to a thickness of about 12mm on the horizontal portion 20 and about 8 1/2mm on the inclined portions 22. The glass fibre reinforced mortar is then rolled in order to compact it.

A reinforcing arrangement is provided for each of the flat-bottomed V-shaped portions 18 by a galvanised steel mesh 24 having a plurality of longitudial elements 26 and a plurality of transverse elements 28 which are welded together. Each element has a diameter of about 2.3mm, and the spacing of the elements is about 50mm. Each mesh 24 is bent so that its shape is complementary to the sprayed GRC layer and is layed onto and becomes at least partially embedded in the surface of the GRC. An elongate trapezoidal section expanded polystyrene former 30 is then suspended above each mesh, and concrete 32 containing a super-plasticiser is poured into each trough formed by the GRC so as to encapsulate the polystyrene formers 30 and provide a level upper face 14 of the panel.

The panel is then cured and demoulded.

The panel 10 fabricated as described above then has a GRC outer surface 12 with a reinforcing mesh 24 embedded at the interface of concrete 32 and the GRC layers.

In use, the panels are assembled as a formwork and then concrete is poured behind the panels and into contact with the surface 14 so that upon curing of the concrete it bonds to surface 14.

Reference is now made to Figures 4 to 6 of the accompanying drawings which show a similar bridge decking panel to that of Figures 2 and 3 and like parts have been allotted the same reference numerals. The important differences are that the reinforcing mesh 24 is confined to the bottom parts only of the flat bottom V-shaped portions 18 and does not extend up the sides of the V-shaped portions as in the previous construction and also that the sections of mesh 24 are wholly embedded in the flass fibre reinforced cement panel. Further important differences are that the polystyrene formers 30 utilised to cast the upper faces 14 of the panels are lodged in the V-shaped portions 18 part-way down the recess thereon to permit a non-structural glass reinforced cement layer to be cast over the formers to a level just below the top surface of the deck panel. Thus a completely enclosed void is created below the formers 30 in the finished structure.

CLAIMS:

1.A building panel composed of, or having an outer layer of fibre reinforced cement, characterised in that an arrangement of tension resistant reinforcement (24) embedded in at least a part of the panel (12) in or adjacent the fibre reinforced cement, the reinforcement comprising a multiplicity of elongate members (26,28) arranged in a mesh with the members secured together where they intersect to constrain the material of the panel throughout the zone in which the reinforcement lies.

2.A panel as claimed in Claim 1, characterised in that the mesh comprises one set of spaced parallel extending elongate elements (26) and a second set of spaced parallel extending elements (28) extending transverse to the first set and secured thereto where they intersect the first set.

3.A panel as claimed in Claim 2, characterised in that the typical length of the fibres in the cement and the size of the spaces in the mesh (24) are of the same order.

4.A panel as claimed in any preceding claim, characterised in that the reinforcement elements (26,28) are of steel or are of plastics material and the elements are secured together by welding.

5.A panel as claimed in any preceding claim, characterised in that the fibre in the cement (12) is of one or more of the following materials: glass fibre, mineral fibre, steel fibre, synthetic fibre or vegetable fibre.

6.A permanent formwork panel comprising a building panel as claimed in any preceding claim.

7.A building structure having an outer surface portion provided by a permanent formwork panel (12) as claimed in any preceding claim, and a structural concrete portion (32) bonded to the permanent formwork panel.

FIG. 1.

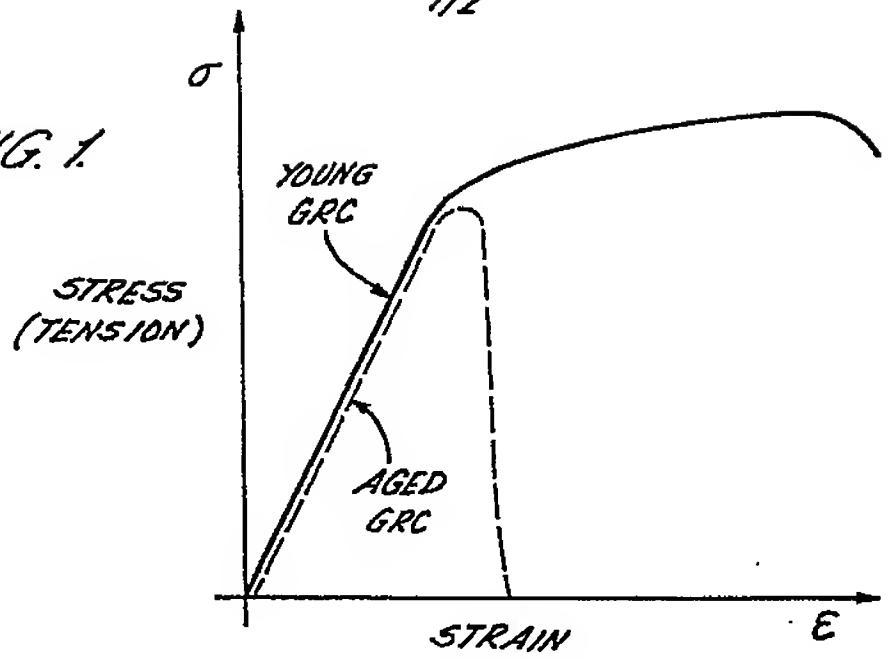


FIG. 2.

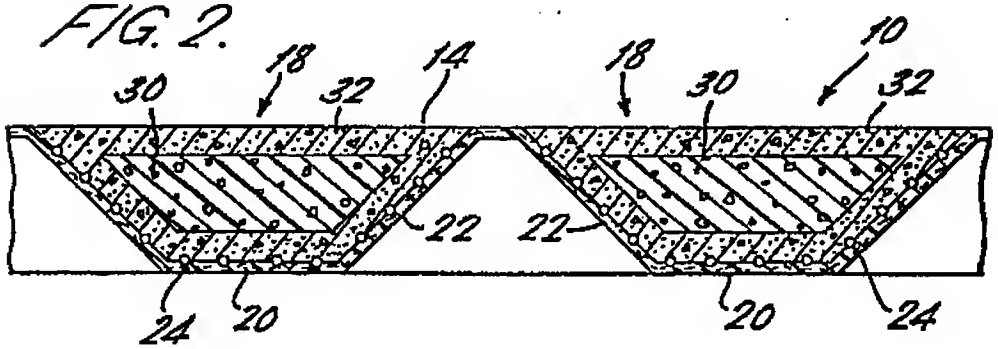


FIG. 3.

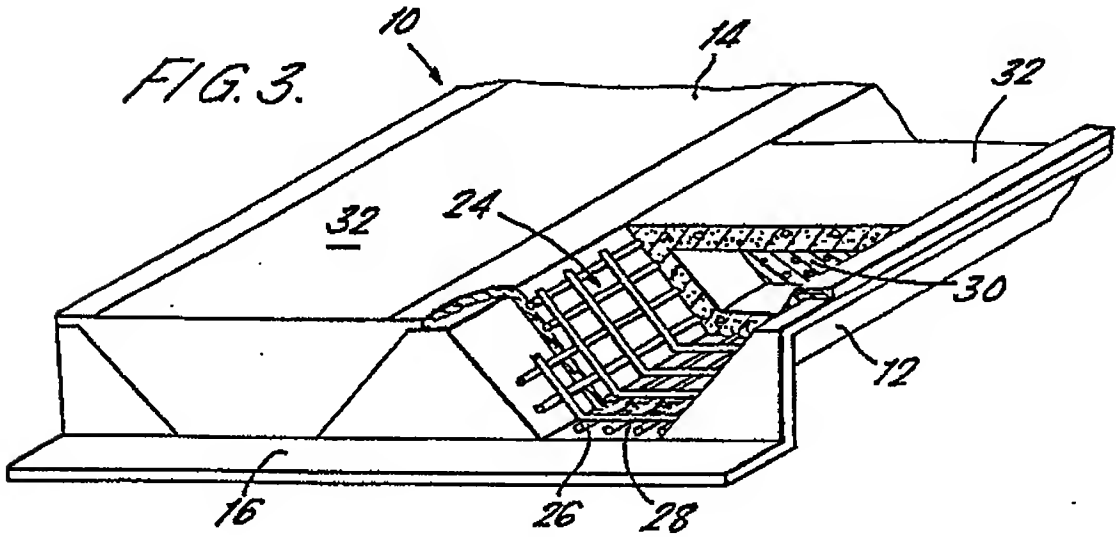


FIG. 4.

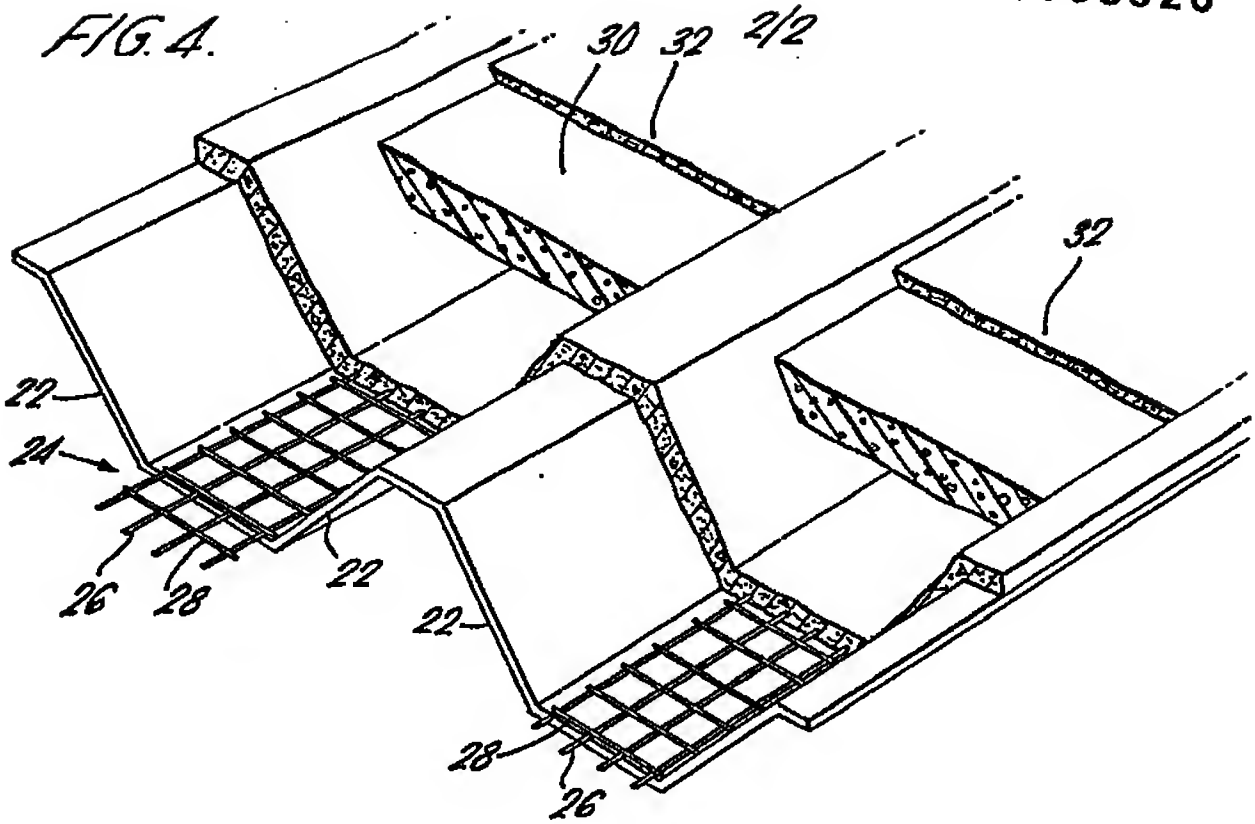


FIG. 5.

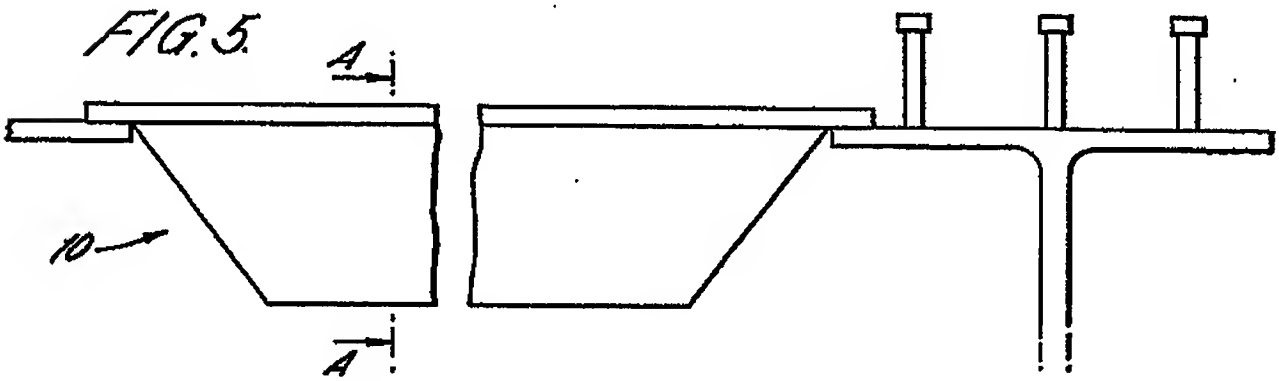
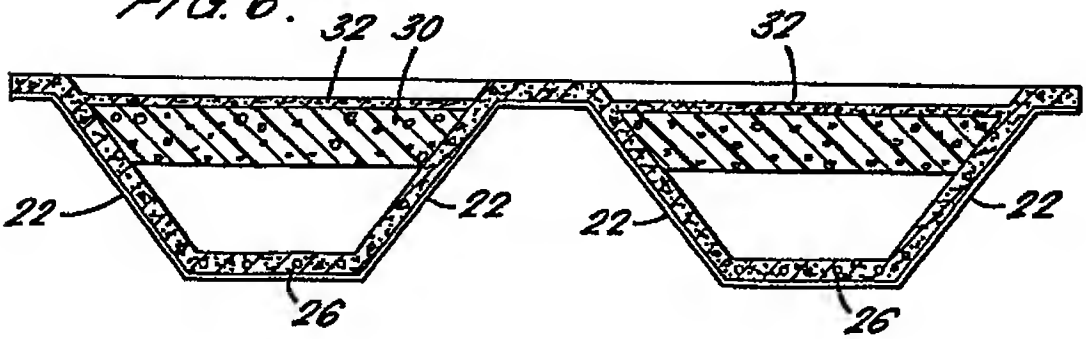


FIG. 6.



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EUROPEAN SEARCH REPORT

0183526
Application number

EP 85 30 8579

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	GB-A-2 026 585 (FIBERHOLD) * Page 1; page 2, lines 1-4; figures 1-3 *	1,6,7	E 04 C 5/07 E 04 C 2/06 E 01 D 19/12
A		2	
Y	GB-A-2 065 742 (KURIMOTO) * Page 1, lines 23-31; page 2, lines 24-65; page 3, lines 1-7; figures 1,2,8 *	1,6,7	
A	GB-A-2 123 048 (SE HONG AN) * Page 2, lines 20-68; figures 2J,2E,2F *	1,2,4	
A	DE-A-2 952 783 (HISTEEL) * Page 9, paragraphs 1-4; figures 3-5 *	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DE-B-2 357 557 (HAARBURGER) * Claims 7,8; figure 6 *	2,4	E 04 C E 01 D
A	EP-A-0 002 267 (SCHEMEL) * Page 4, lines 31-33; page 5, lines 1-11; page 6, lines 18-34; page 7, lines 1-19; figures 1,2 *	1,3,5	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12-02-1986	CHESNEAUX J.C.

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application number 0183526

EP 85 30 8579

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
A	US-A-4 021 258 (SHINOBU) * Column 1, lines 58-68; column 2, lines 1-15,54-68; column 3, lines 1-43; column 6, lines 20-46 *	1,5	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

The present search report has been drawn up for all claims

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THE HAGUE	12-02-1986	CHESNEAUX J.C.

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